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Original scientific paper

IMPACT OF DROUGHT AND SALT STRESS ON SEED GERMINATION AND SEEDLING GROWTH OF MAIZE HYBRIDS

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Radić V., I. Balalić, G. Jaćimović, A. Nastasić, J. Savić, Ana Marjanović-Jeromela (2019): *Impact of drought and salt stress on seed germination and seedling growth of maize hybrids.* - Genetika, Vol 51, No.2, 743-756.
Since maize is grown in climatically diverse regions and under different production conditions, the aim of our study was to investigate the effect of two common stress factors (drought and salinity), on seed germination, as well as on seedling root and shoot length of maize hybrids. The experiments were conducted in 2015, in the Laboratory for Seed Testing of the Institute of Field and Vegetable Crops from Novi Sad, Serbia, on seven maize hybrids from different maturity groups (from FAO 300 to FAO 700). For simulation of drought conditions we have used polyethylene glycol (PEG) 6000 (control and concentration of 1, 10, 16 and 23%). For study of salt stress, NaCl in concentration of 0.02, 0.07, 0.12, 0.17, 0.20 and 0.22 M has been used. The data obtained were processed by ANOVA. Duncan's Multiple Range Test was used to measure statistical differences between treatment methods and the control. In drought stress study, germination percentage started to decrease at the 0.1 MPa. Root and seedling length were less affected by PEG treatment. In salt stress study, a significant drop in germination was observed at the concentration of 0.20 M of NaCl.
Keywords: maize, seed germination, stress, drought, salinity

INTRODUCTION

Worldwide agricultural productivity is subject to increasing environmental constraints in the form of abiotic stresses that adversely influence plant growth and development causing

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crop failure and decreasing average yields (MUSCOLO *et al.*, 2014). Abiotic stress is the primary cause of yield loss worldwide. During their growth crops are usually exposed to different environmental stresses which may limit their growth and productivity (MOUD and MAGSHOUDI, 2008; VUJAKOVIĆ *et al.*, 2011; TUTEJA *et al.*, 2012; KUMARI *et al.*, 2014). Among the abiotic stresses, drought stress is one of the most important environmental factors that reduce growth, development and production of plants (PARTHEEBAN *et al*., 2017). Poor germination and decreased seedling growth result in poor establishment and occasionally in crop failure (ABBASDOKHTA *et al.*, 2014; RADIĆ *et al.*, 2008).

Drought is a multifaceted stress condition that causes serious yield limitations depending on plant growth stage, stress duration, and severity MUSCOLO *et al.*, 2014). Drought tolerance testing in initial stages of plant development is of a vital importance, because the seed with more rapid germination under water deficit conditions may be expected to achieve a rapid seedling establishment, resulting in higher yields (PETROVIĆ *et al.*, 2016). Polyethylene glycol (PEG) is widely used to simulate drought conditions. PEG is an inert osmotic agent whose molecules are too large to penetrate into seed, thus preventing any toxic effects. It does not enter the apoplast, so water is withdrawn not only from the cell but also from the cell wall (PETROVIĆ *et al.*, 2016).

Salinity is one of the major abiotic stress factors and affects almost every aspect of the physiology and biochemistry of plants including seed germination, seedling growth and on the end crop production and yield (SHAO-WEI *et al.*, 2010; YOHANNES and ABRAHA, 2013).

CARPICI *et al.* (2009) state that the high absorption of Na and Cl ions during seed germination inhibit or decrease germination rate and the final germination. Some crops produce acceptable yields at much greater soil salinity than others because they perform osmotic adjustments in order to extract more water from a saline soil (AYERS and WESTCOT, 1989). It has not fully been clarified to which extent seed germination is affected by salinity through osmotic effect and to which extent through ion toxicity. Although each of these stresses differ according to the mode of action and provoke different responses of plants, they can cause a common response in plants which lead to stress tolerance (PETROVIĆ *et al.*, 2016). One of the commonest experiments to study germination of the seeds is application of NaCl to seed and seedling media (KHODARAHMPOUR, 2013; IDRIS and ALI, 2015). Maize seed is inevitably subject to various stress conditions. Maize seed resistance to salinity has been studied by CELIK *et al*. (2010), who determined limit values, after which seed tolerance rapidly decreased. Therefore, it is of great importance to develop maize genotypes with high genetic capacity to tolerate drought and salt stress (KHODARAHMPOUR *et al.*, 2012).

The aim of this study was to assess the effects of drought and increased salt concentrations on seed germination and seedling growth of maize hybrids using laboratory tests.

MATERIALS AND METHODS

The experiments were conducted in 2015, in the Laboratory for Seed Testing of the Institute of Field and Vegetable Crops from Novi Sad, Serbia. Seeds of maize hybrids (NS 300, NS 4030, NS 540, NS 6010, NS 6030, NS 640, TISA) obtained from Institute of field and vegetable crops Novi Sad, Serbia, were sterilized with 0.5% sodium hypochlorite solution for 1 min and after that washed with distilled water. Each hybrid was sown in 4 replicates by 100 seeds for each treatment.

Drought tolerance test

Seeds were incubated on filter paper in Petri dishes, at 25°C. Filter paper was previously treated with polyethylene glycol (MW 6000); using 1, 10, 16 and 23% of PEG concentration corresponding to final osmotic potentials of -0.1, -0.3, -0.6 and -0.9 MPa (SIDARI *et al.*, 2008). Filter paper treated with distilled water was control. We used concentrations of 1, 10, 16 and 23% of PEG to have an osmotic potentional comparable to NaCl concentrations of 0.02, 0.07, 0.12, 0.17, 0.20 and 0.22 M that were tested on seed germination (MUSCOLO *et al.*, 2014).

Salt tolerance test

Seeds of each tested maize hybrid were wrapped in a filter paper previously treated with five concentrations of NaCl (in M): 0.02, 0.07, 0.12, 0.17, 0.20 and 0.22, and placed in a germination chamber, at a temperature of 25°C and relative air humidity between 85 and 95%. The treatment with distilled water was control.

In both tests seed germination was determined after 7 days by evaluating normal seedlings. The germination percentage was determined by counting the number of germinated seeds having 2 mm long radicle (KAYA *et al.*, 2006). Typical or normal seedlings have good following structures: primary root, straight and intact hypocotyl, healthy and whole seedlings and the beginnings of the first true leaves (ISTA, 2014). The radicle and hypocotyl length were measured on 10th and 15th day after sowing.

Statistical analysis

The obtained data were processed by the analysis of variance (ANOVA) procedure for the two-factorial design (STATISTICA 12.0. software, 2009).

Prior to ANOVA analysis for drought tolerance test assumptions were checked and if it was necessary data transformations were applied. Means were compared by Tukey HSD test.

For salt tolerance test, differences between means were tested using Duncan's multiple range test.

RESULTS

Drought tolerance test

Mean squares from the ANOVA showed significant ($P < 0.01$) effect of PEG treatments on studied traits (Table 1). Hybrid main effect had significant ($P < 0.01$) impact on germination percentage and root length. The first order interaction was non-significant for all studied traits.

Table 1. Mean squares from the ANOVA procedure in the study of increasing PEG

		Mean of squares		
Source of variation	Degree of freedom	Germination	Root length	Seedling length
Hybrid	6	84.63^{**}	3.63^{**}	0.04^{ns}
Treatment	4	19798.85^{**}	411.30^{**}	69.50^{**}
Interaction	24	22.77^{ns}	0.47^{ns}	0.02^{ns}

** $P < 0.01$; ^{ns} not significant

As shown in Table 2, seed germination is strongly decreased by increasing PEG concentration. The highest average germination overall PEG treatments was determined in the control (92.71%), while it decreased in all PEG treatments (Table 2). The lowest germination of only 2.9% was determined in the lowest PEG concentration (23%). Hybrid TISA had the highest (52.90%) while NS 300 had the lowest (46.45%) average germination over PEG treatments (Table 2).

Table 2. The effect of PEG on seed germination, root and shoot length of maize hybrids seedlings

PEG treatments (%)	Seed germination (%)	Root length (cm)	Shoot length (cm)
Control	92.7[a]	10.14[a]	3.75[a]
1	78.7[b]	7.73[b]	2.04[b]
10	55.4[c]	4.20[c]	1.10[c]
16	23.8[d]	2.43[d]	0.00[d]
23	2.9[e]	0.78[e]	0.00[d]
Hybrids			
NS 300	46.4[b]	4.46[c]	1.45[a]
NS 4030	51.6[a]	5.53[a]	1.42[a]
NS 540	53.1[a]	5.19[a b]	1.38[a]
NS 6010	52.4[a]	5.51[a]	1.37[a]
NS 6030	48.3[b]	4.62[c]	1.36[a]
NS 640	50.5[a]	4.82[c b]	1.34[a]
TISA	52.9[a]	5.26[a b]	1.32[a]

On average overall hybrids, the longest roots were obtained in control (10.14 cm), while the lowest value of 0.78 cm was determined at the concentration of 23% (Table 2). Hybrids NS 4030 and NS 6010 had the longest roots on average overall PEG treatments (5.53 cm and 5.52 cm, respectively) while the opposite was for NS 300 (4.46 cm). Our results highlighted differences among the hybrids exposed to drought stress with a remarkably decreased seed germination.

The effects of drought stress, cultivars, and their interaction were also significant on root length (Table 2). The highest value of seedling length was found in controls (3.75 cm) and the shortest seedling length value was detected in the last two concentrations (Table 2). Their estimate was 0.0 cm (16% and 23%) and seedlings of these resources did not germinate. Statistically significant differences were determined by comparison of the observed concentrations of PEG (Table 1).

A significant difference in comparison to the two observed parameters is actually higher sensitivity seedling. This sensitivity is expressed at the highest values of PEG concentration. And there is a trend, similar to the previously observed parameters; a significant reduction in the length comes to the concentration of 1% of PEG. In contrast to the previously observed parameters for the seedling length characteristic that at higher concentrations (16 and 23%) does not come to its formation.

Salt tolerance test

The ANOVA F-test applied for germination, root length and seedling length pointed out a significant influence of the treatment, namely NaCl concentration, on these traits. The effects of genotype (G) and the genotype × treatment (G × T interaction) were much lower, i.e. the genotypes reacted in a similar way to the increasing NaCl concentration.

In Table 3. p values indicate (for seed germination and seedling length) that there were no significant effects ($p > 0.05$) for genotype and G × T interaction. Also, there was not sufficient power to detect such effects. Partial η^2 values can help in interpreting the results by indicating the relative degree to which the variance that was found in the ANOVA was associated with each of the main effects (G and T) and their interaction. The results indicate the percentage of variance in each of the effects (or interaction) and its associated error accounted for that effect or interaction (BROWN, 2007). At all three investigated parameters, these values of 0.99, 0.98 and 0.98 indicate that 99 and 98% of the variance is accounted by treatment, whereas genotype and G × T interaction accounts for much less.

Table 3. ANOVA and Univariate Tests of significance, effect sizes and powers for seed germination, root and seedling length, in the study of increasing NaCl

	Effect	DF	SS	MS	F-value	p	Partial η^2	Observed power (α=0.05)
Germination	G	6	75.74	12.62	0.727	0.628	0.03	0.28
	T	6	228729.46	38121.58	2196.305	0.000	0.99	1.00
	GxT	36	501.83	13.94	0.803	0.776	0.16	0.76
	Error	147	2551.50	17.36	-	-	-	-
Root length	G	6	5.39	0.90	2.982	0.009	0.11	0.89
	T	6	2208.52	368.09	1221.905	0.000	0.98	1.00
	GxT	36	8.91	0.25	0.821	0.751	0.17	0.77
	Error	147	44.28	0.30	-	-	-	-
Seedling length	G	6	0.47	0.08	1.219	0.300	0.05	0.47
	T	6	432.92	72.15	1131.804	0.000	0.98	1.00
	GxT	36	0.69	0.02	0.302	1.000	0.07	0.27
	Error	147	9.37	0.06	-	-	-	-

The highest average germination value was determined in the control, while the greatest decrease in germination was notable in the last two molar concentrations of NaCl, which were 0.20 and 0.22 (Table 4). Highest average germination was determined in hybrid NS 540, while the lower value of average seed germination was determined in hybrid NS 6030. There was no significant difference (at level of 5% and 1%) between observed genotypes.

The analysis of the germination in maize seed shows non-significant differences between the control and the first molar concentration (0.02), while between the control on one side and all other molar concentrations on another side there were significant differences (Table 4). A significant difference at the level of 0.05 was between the second (0.07) and the third (0.12) molar concentration, while among the first one and the others there were significant differences at the level of 0.01. A significant difference was determined between the third (0.12) and the fourth (0.17) molar concentrations, while among the third and the remaining molar concentrations there were significant differences at the level of 0.01, too. Significant differences at the level of 0.01 existed between the fourth (0.17) and both the fifth (0.20) and the sixth (0.22) molar concentration, as well as between the fifth and the sixth molar concentrations.

Increasing the NaCl molar concentration affected a linear decreasing of maize seed germination, with this linear decrease different up to a critical concentration (0.17 M), after which the germination increasing was much more rapid (Figure 1). An increase of the molar NaCl concentration of 0.01 decreased the germination for 0.37%. After the critical value of 0.17 M, with an increase of NaCl concentration of 0.01 M, the seed germination decreased for 15.88%. In both regressions, high regression determination coefficient (R_1^2 = 0.99 and R_2^2 = 0.92), were determined.

Table 4. Effects of increasing NaCl concentration on maize seed germination (%)

Hybrids	NaCl molar concentration (M) (T)							Average
	Control	0.02	0.07	0.12	0.17	0.2	0.22	(G)
NS 300	90.00	89.50	88.00	86.25	84.00	24.50	12.75	67.86^{a}
NS 4030	92.25	91.50	90.00	88.25	86.25	19.75	9.00	68.14^{a}
NS 540	93.75	92.75	90.75	89.00	86.75	22.50	12.50	69.71^{a}
NS 6010	92.75	91.75	89.75	88.25	87.00	20.50	10.50	68.64^{a}
NS 6030	92.25	91.00	89.75	88.25	86.00	18.00	8.50	67.68^{a}
NS 640	94.25	93.00	91.00	89.25	87.50	16.75	7.50	68.46^{a}
TISA	93.75	93.50	92.00	89.25	87.00	15.00	7.00	68.21^{a}
Average (T)	92.71^{a}	91.86^{ab}	90.18^{bc}	88.36^{cd}	86.36^{d}	19.57^{e}	9.68^{f}	68.39

$^{a, b, c, d, e, f}$ Treatment means with different letter are significantly different ($p \leq 0.05$).

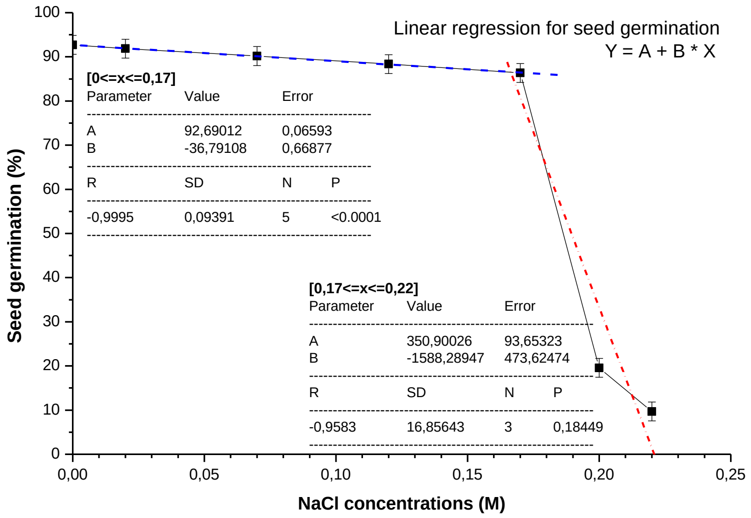

Figure 1. Increasing concentration of NaCl influence on maize seed germination

The greatest value of the root system length was determined in the control, while the smallest value of the root length was determined in the last observed molar concentration, i.e. 0.22 M (Table 5). Lower average value of root length was determined for NS 300 while highest value was determined for NS 4030. Difference, at p level 0.05, was determined between hybrids NS 300 and NS 540 and TISA; as well as between hybrids NS 6030 and NS 4030. Difference, at p level 0.01, was determined between NS 300 and NS 4030, NS 6010 and NS 640. In other cases there were no significant differences.

Table 5. Effects of NaCl on maize seedling root length (cm)

Hybrids	NaCl molar concentration (M) (T)							Average
	Ø	0.02	0.07	0.12	0.17	0.2	0.22	(G)
NS 300	9.18	8.92	8.62	7.46	4.18	2.49	1.07	5.99^{c}
NS 4030	10.57	9.88	9.35	7.60	4.34	2.54	1.37	6.52^{a}
NS 540	10.09	9.60	9.10	7.41	4.23	2.35	1.36	6.30^{ab}
NS 6010	11.08	9.77	8.95	7.50	4.22	2.31	1.14	6.42^{ab}
NS 6030	9.78	9.54	9.03	7.33	4.10	2.31	1.14	6.17^{bc}
NS 640	10.09	9.61	9.23	7.74	4.59	2.55	1.13	6.42^{ab}
TISA	9.92	9.46	9.15	7.35	4.15	2.68	1.21	6.27^{abc}
Average (T)	10.10^{a}	9.54^{b}	9.06^{c}	7.48^{d}	4.26^{e}	2.46^{f}	1.20^{g}	6.30

[a, b, c, d, e, f] Treatment means with different letter are significantly different ($p \leq 0.05$).

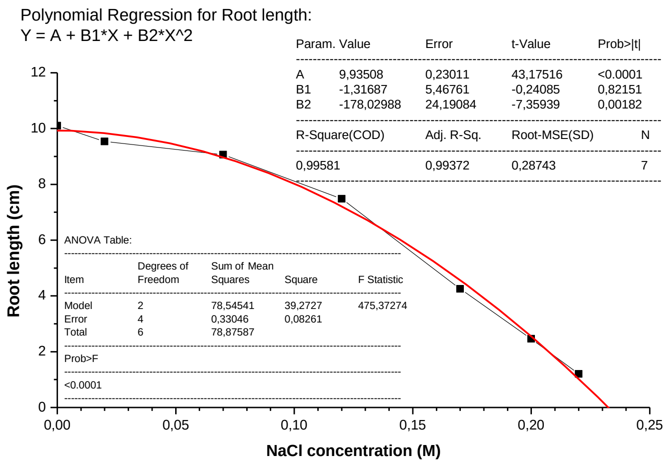

Figure 2. Effect of the increasing NaCl concentration on maize root length

If the trend of decreasing root length is compared to salt concentration, it may be noticed that the observed concentrations decrease this parameter. It was determined that there were significant differences among all observed molar concentrations at the level of 0.01. Such difference was not present only in the case of the first (0.02) and the second (0.07) molar concentration, where the difference was significant only at the level of 0.05 (Table 5).

Unlike in germination, there were significant differences in root length among the tested experimental hybrids (Table 5). The highest differences were determined in the hybrid TISA in comparison to all others. Significant differences lacked only in the case of the NS 4030.

With an increase of the NaCl molar concentration, the maize root length decreased exponentially. This decrease was more moderate in lower concentrations, while a more rapid decrease was present after a molar concentration value of 0.1 (Figure 2). Decreasing the root length with increasing molar concentration may be represented by a square regression equation, with a high determination coefficient (0.99; Figure 2).

The greatest value of seedling length was in the control, while the smallest value (1.16 cm) of seedling length was determined at 0.17 M NaCl. At the last two molar concentrations (0.02 and 0.22 M), there were no seedlings, as a consequence of a high NaCl concentration, (Table 6). There were significant differences among all observed molar concentration values.

Table 6. Effects of NaCl on seedling length (cm)

Hybrids	NaCl molar concentration (M) (T)							Average
	Ø	0.02	0.07	0.12	0.17	0.2	0.22	(G)
NS 300	3.64	3.46	3.19	2.03	1.12	0.00	0.00	1.92[a]
NS 4030	3.89	3.63	3.36	2.00	1.14	0.00	0.00	2.00[a]
NS 540	3.77	3.55	3.27	1.98	1.34	0.00	0.00	1.99[a]
NS 6010	3.97	3.63	3.31	2.05	1.14	0.00	0.00	2.01[a]
NS 6030	3.57	3.36	3.14	2.01	1.11	0.00	0.00	1.88[a]
NS 640	3.64	3.36	3.19	1.99	1.13	0.00	0.00	1.90[a]
TISA	3.74	3.42	3.15	2.01	1.13	0.00	0.00	1.92[a]
Average (T)	3.75[a]	3.49[b]	3.23[c]	2.01[d]	1.16[e]	0.00[f]	0.00[f]	1.95

[a, b, c, d, e, f] Treatment means with different letter are significantly different ($p \leq 0.05$).

The highest average value of seedling length was determined for hybrid NS 6010 while lower value was determined for NS 6030. Significant difference between these two genotypes where determined. In other case's significant difference were not determined.

In average, seedling length had a similar reaction to increasing the salt concentration affecting the seed as in the case of root. By this reason, a significant reduction of seedling length happened at a molar concentration of 0.17. Unlike the previously observed parameter of seedling length, it was typical that at the higher molar concentrations, such as 0.20 and 0.22, its formation was absent (Table 6).

As in the root length, maize seedling length decreased exponentially with increasing the NaCl molar concentration (Figure 3). This decrease was much more rapid in comparison to the formerly observed parameter (Figure 2). Decreasing the seedling length with increasing molar concentration is represented by a square regression equation, with its determination coefficient rather high, like in the formerly observed parameter.

The results show that the germination at lower concentrations decreases less in comparison to decreasing at higher molar concentrations. A rapid decrease of germination begins at a molar concentration of 0.20. Increasing NaCl concentration was highly negatively correlated (r = -0.99** and r = -0.95**) with seed germination. This, however, is not valid in the case of root length and seedling length. In these two there were significant differences already in the beginning concentrations. This gives basis to claim that increasing the salt concentration in a substrate causes decreasing germination, root length and seedling length. The results obtained show a higher susceptibility of seedling in comparison to roots in seedlings, following increasing the NaCl concentration in the substrate.

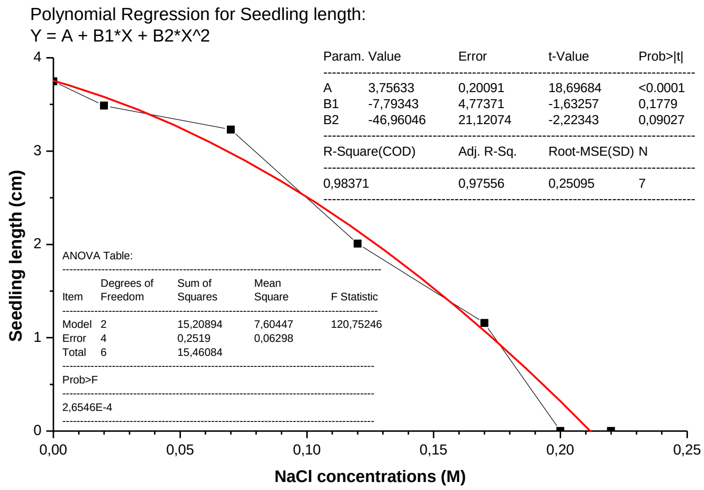

Figure 3. Effect of the increasing NaCl concentration on maize seedling length

DISCUSSION

In this study, seven corn hybrids were compared with regard to their drought and salt resistance to imposed stress in controlled conditions during germination and early seedling growth stage. A similar approach was used to study the comparative effects of water and salt stress on seed germination in sunflower (KAYA *et al.*, 2006), maize (RADIĆ *et al.*, 2008; IDRIS and ALI, 2015) and pea (PETROVIĆ *et al.*, 2016).

Drought tolerance test

Drought is a multifaceted stress condition that causes serious crops yield limitations depending on plant growth stage, stress duration, and severity. Germination is the most critical and sensitive stage in the life cycles of plants (AHMAD *et al.*, 2009) and the seeds exposed to unfavorable environmental conditions such as drought may compromise the subsequent seedling establishment (SOLEYMANI *et al*., 2012; MUSCOLO *et al.*, 2014).

The analysis of variance showed significant differences between solutions for germination values, root and seedling length values. For these traits high influence of PEG concentration on observed parameters was determined. The results showed that seed germination decreases with increasing drought stress. Rapid decrease of germination begins at the first concentration (1% of PEG). MORADI *et al.* (2012) and SHAHRIARI *et al.* (2014) have demonstrated that water stress in sweet corn caused irregular seed germination and poor and unsynchronized establishment of seedlings. Percentage germination decreased with increased PEG concentrations which are due to the reduction in water potential gradient between the seed and surrounding media (ALMAGHRABI, 2012).

Differences between used corn hybrids show their susceptibility on this stress. In this sense, genetic variability within a species offers a valuable tool for studying mechanisms of drought tolerance (SAYAR *et al.*, 2010). The same authors conclude that final germination percentage decreased and delayed as concentration of PEG increased at solution. It also proves that the adverse effect of PEG on germination was due to an osmotic effect rather than to a specific ion. EL-HENDAWY *et al.* (2005) pointed out that both (osmotic and toxic) affects have been implicated in inhibition of seed germination. RADIĆ *et al.* (2008) reported that seed germination is more sensitive to drought stress than growth of established seedling. This conclusion does not apply equally in root and seedling length. Common to both parameters is that there is a significant difference for the initial concentrations. However, the effect of PEG on seedling length is more significant at higher concentrations of PEG, which was found not to come to the formation and development of seedlings. Characteristically, all hybrids were equally sensitive to the effects of increasing negative osmotic potential. This indicates that the seedling length is far more sensitive to the stress conditions then it is root length. The negative impact of drought conditions on the growth of the primary root and seedling were determined by KAYA *et al.*, (2006) on sunflower; KUMAR *et al.*, (2011) on pigeon pea; SHTEREVA *et al.*, (2015) and PETROVIĆ *et al.*, (2016) on pea. They proved that if the seed is treated with PEG, lower concentration can lead to a significant reduction in root length and seedling, and with higher concentrations there has been found seedling.

The results obtained in this study are in agreement with results obtained by SAYAR *et al.* (2010) in wheat, who suggested that drought as stress may affect seed germination and seedling establishment. This decrease or delay always happens. It can be faster or slower and that is in correlation with negative osmotic potential of PEG (different concentration of PEG).

Salt tolerance test

The obtained results on the presence of NaCl in the substrate point out susceptibility of maize seed to this factor, present in many environments. They also point out that the increase of the NaCl concentration negatively affects the germination and seedling development in maize. This is in agreement with previous records of KHODARAHMPOU *et al.*, (2012); KHODARAHMPOU (2013); SOZHARAJAN and NATARAJAN (2014) and IDRIS and ALI (2015). JOVIČIĆ *et al.* (2014) concluded that NaCl can directly affect the growth of the embryo which may adversely reflect on the process of seed germination. Also, NaCl may cause inhibitions of the activities of some enzymes that may play critical roles in seed germination (AL-TAISAN, 2010). Germination and stand establishment are more sensitive to salt stress than later development stages. Salt stress, during germination phase, often delays the start of germination and disperses germination events (FAROQ *et. al.*, 2015).

The second but not less important adverse effect of NaCl is its ability to increase the osmotic potential of the growing media aggravating normal seed imbibition (PETROVIĆ *et al.*, 2016). Na+ ions accumulated in the seed embryo create the difference in water potential between the substrate and the seed, allowing water uptake during germination (SHITOLE and DHUMAL, 2012). CARPICI *et al.* (2009; in corn), SAYAR *et al.* (2010; in wheat), BYBORDI (2010; in canola), SHAO-WEI *et al.* (2010; in tomato), SEPASKHAH and BEIROUTI (2009; in madder) and ALI *et al.*

(2014; in pearl millet and sorghum) in their studies they confirmed that increased salinity tends to reduce seed germination and they showed values for each cultivars that they observed. At equivalent level of stress, NaCl proved more harmful to germination, seedling growth, vigor index, as well as initial mobilizing efficiency of food material from seed to the growing seedling, while PEG-6000 was more harmful to imbibition rate and mobilization efficiency in further days (PETROVIĆ *et al.*, 2016).

CONCLUSION

This study indicated that maize seed is sensitive to abiotic stresses occurring under natural conditions. The study showed that drought tended to reduce corn seed viability. Negative effects were also evident regarding seedling growth and development. The osmotic potential at which seed quality parameters dropped down was 0.1 MPa. Increasing the content of NaCl in the substrate was inversely proportional with germination rate. The differences occurring with low NaCl concentrations were smaller than those occurring with high concentrations. A significant drop in germination occurred with the concentration of 0.20 moles NaCl.

Drought and salt stress are very important abiotic stresses influencing performance of crops. Therefore, the identification or development of tolerant hybrids is of high importance for the maize production. Knowing tolerance is especially important to economic aspect. This research is important for obtaining additional information to maize breeders in searching for characteristics responsible for the survival of plants under stress conditions.

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UTICAJ SUŠE I STRESA SALINITETA NA KLIJANJE SEMENA I RAST KLIJANACA U HIBRIDIMA KUKURUZA

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Izvod

S obzirom da se kukuruz gaji u različitim klimatskim regionima, pod različitim uslovima, cilj rada bio je da se ispita uticaj dva stresna faktora (suša i salinitet), na klijavost semena, kao i na razvoj korena i rast i razvoj korena i ponika hibrida kukuruza. Ogled je izveden u 2015. godini u Laboratoriji za ispitivanje semena Instituta za ratastvo i povrtarstvo Novi Sad, Srbija, na sedam hibrida kukuruza iz različitih grupa zrenja (od FAO 300 FAO 700). Za simulaciju sušnih uslova upotrebljen je polietilen glikol (PEG) 6000 (kontrola i koncentracije od 1, 10, 16 i 23%). Za proučavanje saliniteta upotrebljen je NaCl u koncentracijama od 0,02, 0,07, 0,12, 0,17, 0,20 и 0,22 M. Dobijeni podaci obrađeni su pomoću ANOVA. Dankanov višestruki test intervala upotrebljen je za utvrđivanje razlika između kontrole i upotrebljenih tretmana. U uslovima suše, klijavost semena počela je da opada na tretmanu od 0,1 MPa. Koren i dužina ponika bila je nešto manje osetljiva na tretman PEG-om. U studiji saliniteta, značajan pad klijavosti utvrđen je pri koncentraciji od 0,20 M NaCl.

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